THE PRESENT STATE OF SPONGE SCIENCE

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The status of sponge sciences is assessed over recent decades, examining their strengths, weaknesses, opportunities and threats. The strength of sponge research lies in the organisms themselves, including the very complex array of features this supposedly 'simple metazoan' presents to researchers. We still know very little even about the basic 'bauplan', let alone the myriad of processes associated, and the phylum presents many undiscovered challenges. One of the greatest challenges, and potentially a weakness, is the difficulty in using sponges as experimental subjects outside their home environments, with the likelihood that many in vitro investigations have been flawed. But the future is optimistic, with technology approaching that will allow manipulation of sponge environments sufficient to study various processes in sponges from a range of environments. Multidisciplinary approaches to sponge sciences provides workers with significant opportunity to investigate fundamental biological and chemical problems. This provides us with an opportunity to respond to the political and academic climate by identifying current and future themes, and guiding project directions to meet the demands of the marketplace. Threats to current and future progress in sponge sciences may include the persistence of a narrow focus during disciplinary investigations, and failing to meet the challenge of being dynamic and innovative (with the caution against becoming superficial or 'trendy'). Irrespective of current diminishing funding, agency restructuring and shifts in research priorities, sponge sciences are flourishing and provide reason for current and future optimism. ❐ *Porifera, status of research, strengths, weaknesses, opportunities, threats.*

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The first question is, what are the boundaries of the 'Present' in relation to a group of organisms, which, if you consider just Demospongiae, have been in existence for at least 580 million years in close to their present form and which, judged by their success in recent environments, look set to well outlast those who study them?

After some thought and consultation I have decided to construe the 'Present' as the period since regular sponge conferences began (1968), and extending forward five years from the 5th International Sponge Symposium in Brisbane. In the final keynote paper (Vacelet, this volume), Jean Vacelet will then at least know where the future starts. I will use this forum simply to provide a very brief snapshot of the attention the sponges are receiving and have received through active research programs over that period, and the major achievements.

It was hard to decide how to focus and organise this presentation. I have decided to use a device beloved of our omnipresent bureaucrats and to present the talk as a SWOT analysis which addresses the Strengths, Weaknesses, Opportunities and Threats we, as an international community of sponge scientists, experience. This, of course, will be a personal view, someone else could come up with a very different scenario.

We can think under each of these headings in terms of the 'discipline', things which arise directly from the biology of the organisms we study, and then, 'in context', referring to the dynamics of our group, the scientific trends impacting upon us and the political realities of the day (Table 1).

STRENGTHS. To set a note of optimism, nothing is more obvious than the fact that the major strength of sponge biology lies in the organisms themselves. Sponges, as the simplest true Metazoans, are just incredibly intriguing. They also provide insights into the development of systems which characterise more complex organisms. If we look back over the international conferences since 1968 we can record many milestones passed in our understanding of sponge function and relationships. Many simple elegant

experiments and investigations have been presented and have served to demonstrate sophisticated cellular systems, complex developmental processes, endogenous rhythmic behaviour, cellular communicating networks, incredible versatility in feeding behaviour, amazing chemistry and biosynthetic alternatives, incredible survival of ancient forms, a striving for tissue organisation. Sponges may be the simplest Metazoa but we, as a group of researchers, have demonstrated beyond any doubt that they are also complex organisms.

In light of recent discoveries it occurs to me to wonder whether we have found all the variants upon the basic defining sponge structure or 'bauplan'. May something yet again cause us to reappraise the boundaries of the term Porifera — I can imagine one or two possibilities — but that is for Dr Vacelet, speaking of the 'Future', to tell us about. I think it is justifiable at this stage to contend that the spectrum of disciplines which constitute a holistic approach to sponge biology is being addressed, some disciplines more comprehensively than others — I will return to that.

Strengths contextually arise from the fact that, because of their cellular and chemical basis of operation, it is an absolute necessity to approach questions of sponge function and relationships from a multidisciplinary perspective. Some may have been slow to embrace the molecular methodologies which are simply the tools which can help elucidate cell and organismal function across a broad spectrum. Some may have felt 'rolled over' by the molecular bandwagon, but, now that molecular biology has rediscovered the whole organism, as developmental biology takes centre stage, it is an opportune time to promote the benefits of basic research on sponges.

Lastly, there is the commitment and cohesion of our body of researchers. This is not true of all fields, malacologists are always at war within their community, and entomologists, well, the least said soonest mended! This has been, and hopefully will remain, a communicative, co-operative, congenial and exciting community within which to work.

WEAKNESSES. To temper this, what do I perceive as weaknesses? As you will observe (Table 1), I could not think of many. Sponges are not the most tractable experimental animals, requiring as they do large volumes of sea water to maintain feeding and body form. In the absence of adequate understanding of how they function in nature, many investigations on feeding, response to environmental stresses, cell differentiation and cellular function have been flawed. There is a serious weakness here and the root cause has been the persistent consigning of some biological parameters to the 'too hard' to study basket. This has significantly hampered investigation of ecological physiology and reproductive behaviour, to give just two examples. It is possible that ingenuity in experimental design and/or ability to utilise expensive land based systems can overcome this problem. One possibility I can suggest here is to establish some multidisciplinary collaboration with JAMSTEC, the Japanese Association for Marine Science & Technology, which I was fortunate enough to visit prior to the Otsu Conference. Technology exists there to maintain invertebrates in the laboratory, collected from the deep oceanic vents, and to take them through reproductive cycles. The controls that can be applied in this experimental system surely would permit manipulation of sponge environments sufficient to study physiological and reproductive processes in sponges from a range of environments. The worst thing, however, would be to continue to ignore these areas. A few workers who have 'done the hard yards' in the field have greatly enhanced our knowledge; much more effort is required.

Many would perceive the ageing population of established workers as a weakness in the present context — on the other hand it could be seen as an opportunity. If established positions are retained and deployed in the broad field of sponge biology I perceive no problem. That then becomes the challenge; a test of your political skills in defining and promoting sponge biology in the modern context. Older workers may also, in line with environmental trends, be recycled at greatly reduced cost, surely this is a benefit!

OPPORTUNITIES. I have already noted that the organisms we work on dictate a multidisciplinary approach to almost any serious study. This provides sponge workers with a significant opportunity when presenting applications to granting agencies, which increasingly are requiring such approaches. Sponge models can provide an insight into many fundamental biological and chemical problems. The training that this broadly-based research gives, opens doors for graduates specialising in sponge topics into medicine, particularly in the fields of cell adhesion, cancer biology, immunology, cell differentiation, in the broader field of developmental biology particularly its molecular

aspects, in environmental and conservation management and aquaculture, to name just a few areas where my graduate students have gone.

The fact that sponges inhabit all aquatic environments from the deep ocean to fresh water makes a knowledge of their ecology and reproductive biology an integral part of many multi-agency environmental programs. This provides opportunity to pursue basic sponge research as part of a team.

At present there is opportunity to respond to the new climate in political and academic circles by identifying current and future 'themes' and merging your own interest with these, not being submerged, but guiding project directions to meet the demands of the marketplace and to provide the answers you want as well.

An example from my own experience has been to combine my interest in taxonomy and phylogenetic relationships of sponges with the requirements of those funding marine pharmacological research, always ensuring that I could obtain the data I required through this involvement. Others have taken up similar collaborations. I suggest, however, that biological interests beyond taxonomy, phylogenetics and biogeography can be supported and pursued through selective participation in pharmacologically directed programs.

THREATS. Coming then to actual and potential threats, in many ways the following points apply very generally and are not confined to sponges. However, my thinking is generated from sponge examples. Central to all research is a striving to better and more completely understand how the organisms function and relate to each other and to their environment. Asking the questions — what can a sponge do; what must it have to survive; what can a sponge experience and still survive? — can be enlightening in most, if not all, areas of research.

Such thinking requires, no matter what one's particular specialisation, that you are conversant with developments across the discipline. It is no longer adequate to maintain a narrow focus. These suggestions apply with most force to those of us who are practitioners of the older biological subdisciplines. There has been a tendency for workers to wrap themselves in the mantle of their disciplinary antiquity, new workers being proclaimed not 'true' systematists or 'real' marine biologists if they deploy new techniques or new conceptual approaches to their study. This applies less to sponges than some other disciplines. It is essential that old learning be maintained, but this most often has to take place in new contexts. The eminent philosopher, Alfred North Whitehead, once remarked, 'Knowledge does not keep any better than fish'. There is a challenge then as evolutionary, ecological or systematic biologists, to reilluminate old facts with new insights as well as to make new discoveries. This approach brings a convincing dynamism to our science and is a protection against being declared obsolete. The very real threat lies in failing to meet this challenge.

Having argued the need to keep up with the pace, a caution must be sounded against becoming superficial or 'trendy'. The tools to be applied must be understood and directed to properly formulated questions. To take one example, some of us have engaged in molecular systematic studies attempting to obtain objective data to expand the base upon which classification can be built and relationships can be postulated. Most have worked with the ribosomal gene. However, how many sponge biologists understand the complex, underlying assumptions upon which the tools to deal with sequence analysis rest? That is a discipline in itself, and a highly genetical and mathematical one.

Molecular phylogenies based on ribosomal sequences have implicitly been accorded a higher authority than those phylogenies derived from morphological data sets. Yet, we now know, that particularly for ancient branches, they can be significantly misleading, if not downright wrong. This is particularly so when the number of taxa sampled is low, as has often been the case. There is a significant cost in this work. It is now acknowledged that for deep evolutionary branches it is difficult to have confidence in 18s rRNA trees in the absence of corroborating morphological phylogenies. Sponges are an ancient group already diversified in Pre-Cambrian time. Because of the length of this history, many of our most vexatious higher order taxonomic problems, which rRNA phylogenies hoped to address, probably are subject to a number of artefacts, long branch attraction effects to name just one.

Looking to the future, as molecular systematics comes of age, it seems likely that protein coding genes, which make up a much larger proportion of the genome than RNA coding genes, will provide more reliable phylogenies. Thus it becomes a matter of, choose your question, choose your molecules, choose your

collaborators, and then generate a broadly based morphological and molecular study. It takes time and money; however, superficial exercises waste everyone's time.

Contextual threats can be dealt with quickly. One point arises in part from what I have just said. Failure to develop appropriate collaborations and to determine when to cooperate and when to compete can be a threat to the credibility of the discipline.

Further, and most importantly, it is incumbent on us all to encourage and assist new recruits to the study of sponges. Help at the right time can mean a great deal. Certainly it did for me when as a PhD student, the only person in the Southern Hemisphere working on sponges, I received a letter from Willard Hartman confirming and/or correcting my identifications of a small collection of sponges I had sent him. It made the difference between my continuing with sponges or working in fisheries ecology. Any discipline where helping new workers is ignored is under threat.

Following from this, in view of a perceived lack of present employment, is it ethical to encourage students to study sponges? I think so, provided the training their projects deliver is sufficiently broad to allow adjustment of direction, and we encourage students to think in such terms.

I think the greatest threat to our discipline lies in adopting the common down-beat attitude that years of parsimonious funding and ill-informed managerial changes in direction and philosophy have engendered in universities, museums, and government science agencies. As a group of scientists, devoting research time to organisms the new right would certainly regard as insignificant, we have survived and indeed are flourishing. There is reason for optimism, sponges can almost speak for themselves.

TABLE 1. SWOT analysis of the current status of sponge sciences.

STRENGTHS – DISCIPLINARY
1. the organisms themselves
2. something exciting is always just around the corner
3. the disciplinary spectrum is being covered
4. simple elegant experiments have been done and remain to be done
5. milestones are being passed
STRENGTHS – CONTEXTUAL
1. necessity to take a multidisciplinary approach
2. molecular biology is now rediscovering whole organisms
3. commitment and cohesion of our membership
WEAKNESSES – DISCIPLINARY
1. consigning some biological questions to the 'too hard' basket (e.g. ecological physiology, reproductive behaviour)
2. sponges are difficult material for in vivo laboratory work – expensive systems may be needed
WEAKNESSES – CONTEXTUAL
1. ageing population of established workers
OPPORTUNITIES – DISCIPLINARY
1. multidisciplinary approaches are being demanded by granting agencies
2. sponge models provide an approach to fundamental questions
3. to present basic biological questions in terms and context that can be funded
4. linkages/synergies with many groups possible
OPPORTUNITIES – CONTEXTUAL
1. identifying and manipulating current and future 'fashionable' themes (e.g. sustainability, biodiversity)
2. being able to respond to new academic/political climates and merge your interest with these
THREATS – DISCIPLINARY
1. taking and maintaining a narrow focus
2. failure to understand the organisms
3. becoming superficial and 'trendy'
THREATS – CONTEXTUAL
1. failure to encourage and mentor new workers
2. failure to discriminate when to compete and when to collaborate
3. lack of employment opportunities – is this real?
4. adopting the pervasive down-beat attitude